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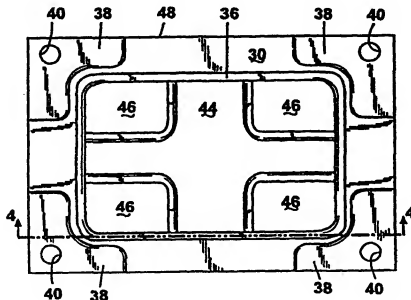
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(71) Demandeur/Applicant:
DANA CORPORATION, US
(72) Inventeurs/Inventors:
CHEN, COLIN CHING-HO, US;
POPIELAS, FRANK WALTER, US;
SHAH, KANU G., US;
PERSON, DENNIS F., US
(74) Agent: RIDOUT & MAYBEE LLP

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(54) Title: FUEL CELL PLATE WITH VARIABLE THICKNESS SEALING BEADS



(57) Abrégé/Abstract:

A fuel cell apparatus includes at least two facing, parallel plates, stacked together but spaced apart by resilient sealing beads disposed on at least one of the plates. The resilient sealing beads are adapted to facilitate control of fluid flows, such as electrolytes, between the plates and are thus called fluid sealing beads. Each plate contains at least one bolt aperture for securing of the two plates together in the described facing, yet spaced apart, arrangement. Separate beads disposed about the aperture(s) act as aperture load compensation beads. In one preferred embodiment, the fluid sealing beads have one uniform thickness, while the aperture compensation beads are wider, however, than the fluid sealing beads. In another embodiment, the thicknesses of the fluid sealing beads may be varied as a function of proximity of any portion of the fluid bead to the bolt hole apertures, with the thickness of aperture beads being less to accommodate anticipated normally higher stress loads at bolted connections. The invention thus results in an improved load stress distribution over the mated plates, as bolt loading is thereby more uniformly spread over the plate areas.



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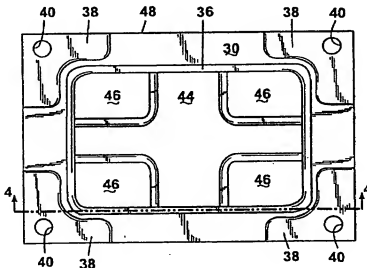
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09/794,674 27 February 2001 (27.02.2001) US(71) Applicant (for all designated States except US): DANA
CORPORATION [US/US]; 4500 Dorr Street, Toledo, OH
43697 (US).

(72) Inventors; and

(75) Inventors/Applicants (for US only): CHEN, Colin,
Ching-Ho [US/US]; 5020 N. Tamarack Drive, Barrington,
IL 60010 (US). POPIELAS, Frank, Walter [DE/US];
1470 Fairway Drive, #202, Naperville, IL 60563 (US).
SHAH, Kanu, G. [US/US]; 1932 N. Brighton Place,
Arlington Heights, IL 60004 (US). PERSON, Dennis, E.
[US/US]; 1820 East Gate Parkway, Rockford, IL 61108
(US).(74) Agents: STEWART, Michael, B. et al.; Rader, Fishman
& Grauer PLLC, 39533 Woodward Avenue, Suite 140,
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(54) Title: FUEL CELL PLATE WITH VARIABLE THICKNESS SEALING BEADS



(57) Abstract: A fuel cell apparatus includes at least two facing, parallel plates, stacked together but spaced apart by resilient sealing beads disposed on at least one of the plates. The resilient sealing beads are adapted to facilitate control of fluid flows, such as electrolytes, between the plates and are thus called fluid sealing beads. Each plate contains at least one bolt aperture for securing of the two plates together in the described facing, yet spaced apart, arrangement. Separate beads disposed about the aperture(s) act as aperture load compensation beads. In one preferred embodiment, the fluid sealing beads have one uniform thickness, while the aperture compensation beads have another thickness less than that of the fluid sealing beads. In the same embodiment, the aperture compensation beads are wider, however, than the fluid sealing beads. In another embodiment, the thicknesses of the fluid sealing beads may be varied as a function of proximity of any portion of the

fluid bead to the bolt hole apertures, with the thickness of aperture beads being less to accommodate anticipated normally higher stress loads at bolted connections. The invention thus results in an improved load stress distribution over the mated plates, as bolt loading is thereby more uniformly spread over the plate areas.

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1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000 1001 1002 1003 1004 1005 1006 1007 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017 1018 1019 1020 1021 1022 1023 1024 1025 1026 1027 1028 1029 1030 1031 1032 1033 1034 1035 1036 1037 1038 1039 1040 1

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

FUEL CELL PLATE WITH VARIABLE THICKNESS SEALING BEADS**BACKGROUND OF THE INVENTION****Field of Invention**

5 The present invention relates to improved fuel cell assemblies for generating power, and more particularly to improved sealing structures applied to individual fuel cell plates secured together via bolted connections.

Description of the Prior Art

10 It is known to apply resilient sealing beads to the faces of fuel cell plates for control of fluid flows between a plurality of such plates stacked and bolted together for such purpose. In a typical fuel cell arrangement, pluralities of such plates are sandwiched together in a parallel, face-to-face pattern during the conventional assembly of a fuel cell apparatus. The plates are held spaced apart by resilient sealing beads adhesively bonded to the face of at least one of any two adjoining plates. The sealing beads define paths or channels for fluids to flow between the plates, and thus fluid electrolytes are used to transfer energy in this manner as will be appreciated by those skilled in the art.

15 The cell plates employed in the usual fuel cell are brittle, as they are typically formed of composites that include graphite. Thus, special care must be taken with respect to the handling of the plates during fuel cell construction, manufacture, or repair to assure that the brittle plates will not be damaged or compromised. Such care extends even to the post-manufacture handling of the fuel cell to avoid physically bending or cracking of the brittle plates.

20 The brittleness issue is particularly exacerbated by the use of bolted connections through apertures distributed about the periphery of the stacked plates. In such cases the apertures may be spaced significant distances from intermediate areas of the plates that contain the fluid sealing beads adapted to control flows of electrolytes between the plates. Thus, the torquing of the bolted connections for securement of the plates together may actually introduce bending moments in the plates, as the intermediately positioned fluid sealing beads tend to counteract the tightening of bolts about the peripheral edges of the

plates. Such moments tend to eventually lead to cracking of the brittle plates, particularly during any post-manufacturing handling of fuel cell structures, as noted.

SUMMARY OF THE INVENTION

The present invention provides an improved fuel cell plate construction, wherein
5 sealing bead thickness is controlled over the surface area of the plate, including those areas about bolt apertures used for securing the plates together, in an effort to alleviate over-stressing or cracking of the normally brittle plates. Thus, a plurality of parallel, stacked plates which incorporate the present invention are separated by a plurality of discrete sealing beads disposed over at least one of any two facing plates. In a preferred form, the
10 sealing beads are applied to the faces of the plates by screen-printing techniques to produce accurate thicknesses. The sealing beads are resilient, preferably formed of an elastomeric material, and have varied thicknesses or plate surface heights to accommodate variations in stress levels produced when such plates are bolted together under conventional fuel cell manufacturing techniques. Thus, upon installation of a plurality of fuel cell plates together
15 via bolted connections, the beads are adapted to maintain desired separations between the stacked plates.

To the extent that the highest localized stress areas typically occur in regions immediately adjacent bolt apertures, this invention provides for sealing beads of lower heights or thicknesses about the bolt apertures than for the fluid sealing beads spaced away
20 from the bolt apertures and normally adapted to accommodate fluid flows. In the same preferred embodiment, the sealing beads about the bolt apertures are wider, though of lesser thickness, than the fluid sealing beads. Thus, the fuel cell plates of this invention have compensating thicknesses and widths of the sealing beads about the bolt apertures relative to fluid sealing beads that share the same plate, in order to minimize stress
25 fractures and related premature deterioration of the fuel cell plates.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a plan view of a fuel cell plate of the prior art, which includes only fluid sealing beads; i.e. sealing beads only in areas spaced away from, or not associated with, apertures.

Figure 2 is a cross-sectional view along lines 2-2 of Figure 1.

Figure 3 is a plan view of a fuel cell plate of a preferred embodiment of the present invention, which includes sealing beads of varied heights or thicknesses in both fluid path areas as well as around the bolt aperture areas.

5 Figure 4 is a cross-sectional view along lines 4 - 4 of Figure 3.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring initially to Figures 1 and 2, a prior art fuel cell plate 10 is shown, which includes contiguous lengths of a conventional single fluid sealing bead 16, formed of width
10 and height suitable for appropriate control of electrolyte flows in fluid path areas 18 between the beads, after the plates 10 and 12 have been bolted together. The plate 12 is beadless as shown, though if part of a plurality of fuel cell plates comprising a fuel cell, the plate 12 would likely contain a contiguous bead 16 similar to that disposed on the plate 10.

Referring now specifically to Figure 2, a pair of mated bolt hole apertures 20 of
15 plates 10 and 12 are normally secured together by bolts (not shown). When tightened, the bolts will draw the underside 14 of the upper plate 12 downwardly against the top of the resilient elastomeric bead 16. Those skilled in the art will appreciate that any inadvertent over-torquing of the bolts may over-compress the bead 16, which will cause the bolted
20 areas (20) of the plates 10 and 12, spaced away from the bead 16, to bend together and create undesirable bending stresses in the plates. As noted, such stresses can cause the plates to develop stress cracks, which can ultimately lead to premature failure of the plates, and hence of the associated fuel cell assembly, particularly if the plates are formed of brittle composites, such as those including graphite.

Referring now to Figures 3 and 4, a pair of mated fuel cell plates 30 and 32 is
25 constructed in accordance with one preferred embodiment of the present invention. The bottom plate 30 contains resilient beads 36 and 38, as shown. The top plate 32 is shown beadless for convenience of description, but would also likely contain beads 36 and 38 if incorporated in a stack of parallel graphite plates to form a commercial fuel cell assembly. Fuel cell plates as typically used in the applications as herein described are in the range of
30 one-fourth inch thickness each, and often include grooves (not shown) for facilitating fluid flow.

The beads 36 are called fluid sealing beads, and the contiguous lengths of the beads 36 are adapted for maintaining appropriate fluid channels 44 and 46 between the fuel cell plates 30 and 32 after the latter are bolted together through apertures 40 via bolted connectors (not shown). In a first preferred embodiment, the contiguous fluid sealing beads 36 have a unitary or single thickness "T" as shown in Figure 4. Normally, the thickness "T" would be approximately 0.10 inch.

The beads 38, on the other hand, act as bolt load compensation beads rather than sealing beads. Thus, the beads 38 are called load compensation beads, and for this purpose the beads 38 are disposed about each bolt aperture 40. The beads 38 have a unitary, lesser, thickness "t" to accommodate higher anticipated localized loading at bolted connection areas (40) of the plates 30 and 32. The thickness "t" is approximately 0.05 inch. The beads 38 are also substantially wider than the beads 36 for spreading the higher bolted connection loading over a greater area. Thus the beads 38 are specifically adapted for counteracting plate bending moments associated with the bolting together of the fuel cell plates 30 and 32.

In the described preferred embodiment, the contiguous bead 36 acts as a resilient separation barrier between the plates 32 and 30. The internal borders of the contiguous bead 36 define the described fuel cell electrolyte fluid channels 44 and 46. Such channels 44 and 46 will normally be confined to the medial area of the plates, while the bolt load compensation beads 38 will be normally situated at the apertures 40, disposed about the peripheral edges 48 of the plates 30 and 32. Referring now to Figure 4, it will be appreciated by those skilled in the art that the load compensation beads 38 must be of lesser thickness than the sealing beads 36. Moreover, it will be particularly advantageous if the beads 38 are also wider than the beads 38. Thus, thinner but wider bolt aperture compensation beads 38 are effective to resist bending of the plates. In order to appreciate this concept intuitively, one has only to reverse the relative thicknesses of the respective beads 36 and 38 as depicted in Figure 4. It will then be fully realized that a thicker bead 38 at the peripheral edges 48 of the plates 30 and 32 would not facilitate securement of the upper plate 32 down against the top of the bead 36 to adequately seal the channels 44 and 46. Indeed, the compression forces created by the bolting of the apertures 40 would remain entirely about the edges 48 of the plates.

Referring now particularly to Figure 3, the deposition of the resilient beads 36 and 38, both preferably of an elastomeric material, is feasibly achieved by screen printing. Those skilled in the art will appreciate that screen printing will accommodate both the thicknesses and the widths required to achieve the proposed configurations.

5 Finally, even though the beads 36 and 38 as described are of uniform thicknesses, this invention contemplates that the beads may alternatively be varied as a function of distance from the bolt apertures. Thus, each bead 36 and 38 could have variable thicknesses, each being adapted to reduce variations in plate stress as a function of
10 proximity of each bolt aperture to any portion of either bead. In each case however, the first sealing bead would have its greatest thickness that points furthest from any one of said apertures, as will be appreciated by those skilled in the art.

 It is to be understood that the above description is intended to be illustrative and not limiting. Many embodiments will be apparent to those of skill in the art upon reading the above description. Therefore, the scope of the invention should be determined, not with
15 reference to the above description, but instead with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled.

WHAT IS CLAIMED IS:

1. An apparatus comprising at least two plates aligned in parallel, facing yet spaced, proximity to one another, each of said plates comprising at least one bolt aperture, each said aperture of one plate being in alignment with at least one aperture of the other plate, a first resilient bead disposed over a portion of the surface of one of said plates spaced from said apertures, said bead having a first thickness and adapted to comprise a resilient barrier of separation between said plates, and wherein said areas of separation comprise sealed channels between said plates, upon securement of said plates together via bolt members passing through said apertures; a second resilient bead disposed about and adjacent said aperture of said one of said plates, said second resilient bead having a second thickness less than said first thickness of said first bead, said different thicknesses of said first and second beads providing reduced stress level variations throughout the plates upon bolted securement of said plates.
2. The apparatus of claim 1, wherein said resilient beads are comprised of an elastomeric material.
3. The apparatus of claim 2, wherein said second resilient bead is wider than said first bead.
4. The apparatus of claims 3 wherein said plates are fuel cell plates formed of a relatively brittle material.
5. The apparatus of claims 3 wherein said plates are fuel cell plates formed of graphite material.
6. The apparatus of claim 4 wherein a plurality of said fuel cell plates are sandwiched together, each plate having said first and second resilient beads disposed on one side thereof.
7. The apparatus of claim 6 wherein a plurality of said apertures are formed in each plate, wherein the preponderance of said apertures are situated at the edge of any given plate.

8. The apparatus of claim 7 wherein said first and second resilient beads act as fluid sealing beads and aperture bolt load compensation beads, respectively.

9. The apparatus of claim 1 wherein said first and second resilient beads have a plurality of thicknesses, each adapted to reduce variations in plate stress as a function of the proximity of each bolt aperture within said plate to said first resilient bead.

10. The apparatus of claim 9 wherein said bolt apertures are disposed about the periphery of said plates, and wherein the first resilient bead has a thickness that is variable as a function of the proximity of any one of said apertures to said first resilient bead, wherein said first resilient bead has greatest thickness at points furthest from any one of
5 said apertures.

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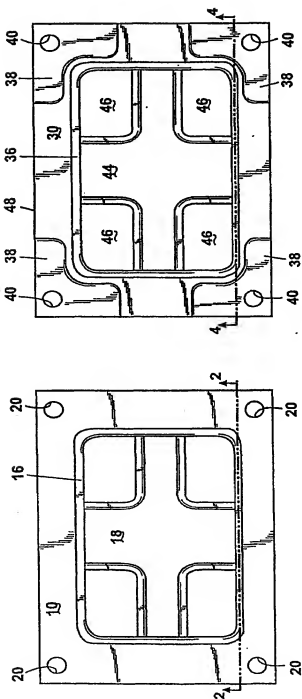


Fig. 3

Fig. 1 (PRIOR ART)

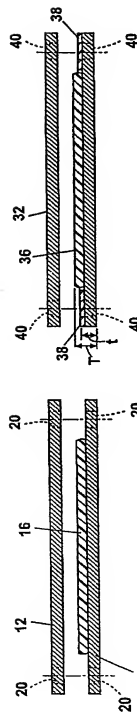


Fig. 4

Fig. 2 (PRIOR ART)